Integrated Pest Management (IPM) Plan

CRANEY ISLAND DREDGED MATERIAL MANAGEMENT AREA

MOSQUITO SURVEILLANCE & CONTROL

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I. INTRODUCTION

This integrated pest management plan (IPM) provides an overview of the process that will be used to implement the mosquito surveillance and control of the Craney Island Dredged Material Management Area. This IPM is based on currently available information, and addresses the activities to be accomplished for mosquito surveillance and control.

Much of the information in this IPM is taken from the recent *Virginia Arbovirus Surveillance Response Plan* (2004) prepared by the Virginia Interagency Arbovirus Task Force.

II. LOCATION DESCRIPTION

The Craney Island Dredged Material Management Area (CIDMMA) was constructed on an area of open water adjacent to Craney Island in Portsmouth, Virginia. The placement area is approximately 2,500 acres in size and is sub-divided into three containment areas. The Craney Island project also includes additional features such as a re-handling basin for unloading dump scows, and a wharf for the unloading of debris and solid dredged materials.

III. MOSQUITO SURVEILLANCE

An effective mosquito surveillance program provides an estimate of species abundance and distribution. Data collected is used to estimate risk levels, guide control operations, and evaluate various control methods.

The following objectives serve to obtain the necessary information about local mosquito populations:

1) Identifying the mosquito species that are present;
2) Identifying the mosquito species that are the cause of local citizen complaints, and determining whether they are important West Nile Virus (WNV) vector species;
3) Identifying and mapping mosquito breeding habitats for larval control purposes;
4) Defining the geographic area that needs to be treated to control adult mosquitoes;
5) Estimating the desired trigger threshold (population density) for initiating control;
6) Determining when local mosquito populations are at an appropriate developmental and/or behavioral stage to apply control measures;
7) Determining the effectiveness of local mosquito control measures;
8) Determining whether vector mosquito species are present in an area, and

whether they are infected by WNV and/or other arboviruses;

9) Determining the mosquito infection rate (MIR) for WNV or other arboviruses in a vector species population; and
10) Determining the seasonal activity patterns of local mosquito species;

A. Surveillance Methods

Mosquito surveillance involves numerous different strategies and practices. A variety of different methods are used to trap mosquitoes in the field because different mosquito species have different behaviors and biology and cannot all be collected by the same method. For example, some mosquito species are readily caught in traps whereas other species are rarely collected in traps. Different types of traps are used for different species of mosquitoes. Also, larval mosquitoes occupy different environments than adult mosquitoes, so collection methods used for larvae are much different than those used for adults. For arboviral surveillance, appropriate species of adult mosquitoes should be collected, pooled and submitted to the laboratory for arboviral testing. Surveillance should be utilized for determination of arboviral risk as well as for planning, execution, and evaluation of control practices.

1. Larval Surveillance

Surveys of immature mosquitoes are an important aspect of the surveillance program, and for certain species, larval surveillance may be a more accurate measure of mosquito population density than adult trapping. Larval surveillance is essential for the appropriate targeting of larval control methods.

Larval surveillance should begin early in the season, even before adults are active to help identify the breeding sites of vector species so that larval control efforts can be targeted. Larval surveillance can be conducted as part of inspection and complaint investigation activities and is often done in conjunction with the application of larvicides for control. In areas where there is no baseline mosquito surveillance data, larval samples can be used to identify and map vector-breeding sites. This information can then be used to help in determining appropriate trap locations to monitor adult mosquito populations.

Larval surveillance requires the use of minimal and inexpensive equipment. Equipment should include: a long handled dipper; a small soup ladle (for dipping into tires or small holes); a small white, plastic or enamel pan (to dump dip samples into for close observation and detection of very small larvae); a turkey baster (for sample transfer); Whirl-pak ® larval collection bags (for collection of larval samples); a tea strainer (used to pour off excess water to concentrate larval samples); and a shoulder bag (to carry equipment in). Larval surveillance may require the use of different dipping techniques depending on the target species and habitat (see Larval Surveillance Procedures, Attachment A). Accurate records should be kept of when and where larvae are collected (see Larval Surveillance Data Form, Attachment A).

2. Adult Surveillance

Because it is the adult female mosquito that carries and transmits diseases, many surveillance techniques have been devised to collect adult female mosquitoes to monitor or record their activities. Techniques include the use of trapping, mechanical aspirators, and documentation of mosquito activity through citizen complaints. Trapping is widely used, but day-to-day success may be variable due to variation in environmental conditions such as wind, air temperature, rainfall, and trap location. Several different types of traps are used and each type is used to trap certain species of mosquitoes. There are also certain mosquito species that will not be attracted to traps and which must be collected by some alternative means.

It is often advisable to use several types of traps (e.g., gravid traps and CDC-light traps) at a single trap site to collect a representative sample of the species active at that location. Data on the trapped mosquitoes should be maintained to create a historical record of mosquito species found in association with different habitats. Trapped mosquitoes that have been identified can either be logged into a computerized mosquito database, or may be logged onto a paper data sheet for future data entry.

The most common trapping and adult collection and monitoring methods used include:

a. **Reiter gravid trap -** The Reiter gravid trap is designed to collect gravid mosquitoes and is among the most important mosquito traps used for WNV surveillance. Gravid mosquitoes are mosquitoes that are carrying eggs and are seeking a place to lay them. The gravid trap was originally developed for monitoring mosquitoes in the *Culex pipiens* complex for St. Louis Encephalitis surveillance. Gravid traps will also work for trapping several of the *Aedes* and *Ochlerotatus* species that breed in containers and may be important arbovirus vectors (e.g. WNV). Gravid traps are the most effective means of collecting *Culex pipiens* and *Cx. restuans* which are the most important “primary vectors” of WNV (primary vectors are those species responsible for transmitting WNV to the bird population). The container breeding *Ochlerotatus* and *Aedes* species captured in gravid traps include: the Asian tiger mosquito (*Aedes albopictus*), the Eastern tree-hole mosquito (*Ochlerotatus triseriatus*), and the newly introduced Asian rock-pool mosquito (*Oc. japonicus*). These species are potentially among the most important “bridge vectors” for WNV and LAC (bridge vectors are those species which can bite birds, and commonly bite humans or other mammals and serve as a bridge for the virus to move from bird to mammal). *Ae. albopictus* might also be an important EEE vector.

Gravid traps use a small electric fan, typically powered by a 6-volt lantern battery to suck up the mosquitoes that visit the bait container, and blow them into a collection bag. Gravid traps are baited with a tub of smelly infusion (tea or fermented brew) made from water and organic material (e.g. grass clippings, hay, dead leaves, yeast, pelleted rabbit chow, horse manure, etc.). When trapping *Culex* species it is best to use a bait infusion made from a recommended formula (see Attachment B for a formula used to make a highly effective gravid trap bait for *Culex* species). Gravid *Culex* mosquitoes are attracted to the smelly water infusion as a place to lay their eggs. There is a higher probability of collecting virus-infected mosquitoes in a gravid trap than in a light trap because gravid traps attract female mosquitoes that have already taken at least one blood meal and are ready to lay eggs. The species collected may vary by where the trap is set and/or what formula is used to make the infusion bait. Traps are best set under bushes, under porches, in tall grass, or out of the wind in areas close to where target vector species may be seeking a place to lay eggs. When trapping any mosquito species, gravid traps are best set sometime between 2:00 and 4:00 PM and collected the next day around 8:00 or 9:00 AM. Gravid traps collect live mosquitoes, and fresh specimens are preferred for arboviral testing; virus isolation by tissue culture works best in mosquitoes that have been dead for less than a day.

a. **CDC light trap (Attachment C) -** CDC light traps are one of the standard tools for adult mosquito surveillance. Like the gravid trap, this trap is very portable because it is lightweight and can be powered by a 6-volt lantern battery. The CDC light trap uses a small light source to attract and capture mosquitoes that are seeking a host for a blood meal. Unlike the gravid trap, a CDC type light trap attracts a relatively wide variety of species and because of this, is the best trap to use for identifying the species composition of a locality. The CDC light trap is highly effective for trapping and monitoring various species of floodwater and marsh mosquitoes, but may only be marginally or poorly attractive to other species including *Culex pipiens* which is more attracted to gravid traps. The CDC light trap is the best tool for monitoring *Culiseta melanura*, the primary vector for EEE, and for monitoring many of the important bridge vectors of WNV and EEE. Baiting the trap with CO_2 increases both the number of mosquitoes and range of species collected, as compared to traps using light as the sole attractant. Use of CO_2 to bait the trap requires a supply of dry ice, or canisters of compressed CO_2; a trap baited with CO_2 may require 2-3 pounds of dry ice or compressed gas per night. Mosquitoes are trapped live, and this feature helps maintain the freshness of mosquito specimens that are being tested for arboviruses. CDC light traps use only a small light source that attracts relatively few non-mosquito, insect species such as beetles and moths. It is best not to trap non-mosquito species because they make sorting and identification a lot of work, and/or damage the trapped mosquitoes. The CDC light trap collects mosquitoes that are mostly undamaged and this makes them easier to identify.

b. **New Jersey light trap (Attachment D) -** This trap has historically been a major component of mosquito abatement programs, but is not very useful for arboviral surveillance. These traps use a 25-watt light bulb as an attractant, and a fan draws the insects into a collection jar, which is usually equipped with a vapona strip as a killing agent. One disadvantage of New Jersey light traps is that they are large and heavy, and require standard electrical current. That limits trap placement to locations where there is availability of electricity. Another disadvantage is that many large, non-mosquito insects are attracted to the light bulb used in the New Jersey trap, and these larger insects often damage the collected mosquito specimens badly enough that identification is impossible. Unidentifiable, dead specimens are not useful for arboviral testing. Two important target species for WNV surveillance (C*ulex pipiens* and *Aedes vexans*) are attracted to New Jersey traps, and in areas where these species are the predominant mosquito, a New Jersey light trap can be used to monitor their relative population density over time. New Jersey traps are best used in areas where only a few predominant species occur (e.g., near a salt marsh). In such locations the collected species do not need to be identified and the trap catches only need to be counted to provide relative mosquito numbers, from week to week as a means of directing adult mosquito control activities. The Craney Island Dredged Material Management Area would be a good location for this type of trap.

c. **<u>Mechanical Aspirators</u> -** Powered aspirators are useful tools for collecting adult mosquitoes. Some species of mosquitoes (e.g., certain species in the *Anopheles* and *Culex* genus) do not readily come to traps and aspirating them from their resting areas is the only way to collect them in significant numbers. Aspiration is the best way to collect *Anopheles* mosquito species involved in malaria transmission. All mosquito species rest after taking a blood meal and the only way to capture certain mosquito species while they are blood-fed or gravid is to seek out their resting shelters and aspirate them. Blood-fed or gravid mosquitoes are more likely to be infected with an arbovirus such as WNV or EEE. Mosquito resting places include: foliage of certain plants; building walls, ceilings and eaves; the undersides of bridges; the insides of hollow trees and logs; rodent burrows; and the insides of culverts or sewer pipes. Mosquitoes can also be collected with aspirators when they enter vehicles, or swarm around personnel during trap setting activities. Power aspirators range in size from small hand-held, battery powered units to larger battery or gasoline powered backpack units.

e. **<u>Citizen Complaints</u> -** If the public is informed about whom to call, citizen complaints about adult mosquito activity, or about potential breeding habitats are useful for mosquito surveillance. Maintaining records of citizen complaints, can contribute toward identification and mapping mosquito problem areas. Citizen complaints can be useful when establishing a new surveillance program in an area where the mosquito breeding habitats and/or areas affected by adult mosquito activity have not yet been identified. Citizen complaints can be mapped as points on a map, and clusters of points will indicate a persistent problem area. Complaints can also be investigated through visitation and direct observation, trapping and/or aspiration of adult mosquitoes and larval dipping in identified habitats.

A sizable portion of citizen complaints are unfounded or misidentify the source of the mosquitoes, so it may take a person with some knowledge of mosquito biology to question the complainant and get the complete and pertinent facts. Obtaining detailed information from the caller (e.g., what time the mosquitoes were active, whether they were biting or not, what their biting behavior was, how large the mosquitoes were, what the mosquitoes looked like, whether there are any suspected breeding grounds near by, etc.) will help screen complaints and avoid unnecessary visitations/investigations. For example, adult mosquitoes are relatively small and are generally difficult to observe, so people do not normally notice them unless they are biting or trying to bite. There are thousands of small flying insects species that might be mistaken for mosquitoes, so if the insects noticed by the complainant were not trying to bite or biting, it is probably unlikely that they were mosquitoes. Questioning the complainant about the time of day mosquitoes were biting is a useful screening tool. For example, Asian tiger mosquitoes are one of relatively few mosquito species that bite during the daytime (daylight hours) and because most complaints in Virginia are related to Asian tiger mosquito activity, determining that the mosquitoes are biting during daylight hours will indicate that the problem mosquitoes are most probably Asian tiger mosquitoes. Also, Asian tiger mosquitoes only breed in containers (not in puddles or ground pools) and because they generally do not move far, they probably have originated from a container on the complainants property, or from one that is on a neighbor's property. Therefore, if the complainant is indicating that the mosquitoes are biting during the daylight hours and that they originate from a nearby pond or ditch, the person taking the complaint will know that the identified habitats are an unlikely source.

3. Mapping and Analysis of Mosquito Surveillance Data

Surveillance activities should include locating mosquito breeding habitats and defining the geographic range (area) affected by adult mosquitoes from an identified habitat. Habitats and areas of adult activity can be marked on paper maps and used for reference when planning control activities. The use of Global Positioning System (GPS) devices is recommended for accurate mapping, and is indispensable for mapping with computer based Geographic Information Systems (GIS) software. Use of GIS requires good surveillance data management. GIS mapping allows the incorporation of many map layers that include such information as: road layout, jurisdictional boundaries, human population density, aquatic and/or wetland habitat types, topography, aerial photography indicating vegetation zones, etc. These many map features can aid in the analysis of mosquito data, or in the planning of control programs.

4. Virus Testing of Adult Mosquitoes

It is not appropriate to submit all mosquito species for arboviral testing. Surveillance programs should concentrate on trapping and submitting approved vector species for testing (see approved list, Attachment E). Collected mosquitoes should be pooled for testing. Pools of most approved mosquito species consist of 25 to 50 individual mosquitoes of the same species from the same location and collection date. Certain important vector species may be submitted in pools of as few as 10 mosquitoes. The labs will not test pools containing fewer than 10 mosquitoes unless the submitter has obtained prior approval to submit them. Approval can be obtained by contacting Dr. David Gaines, (Public Health Entomologist, VDH-Office of Epidemiology, Tel. [804] 864-8141; david.gaines@vdh.virginia.gov), and/or by contacting personnel in charge of testing at the laboratories (see Attachment E).

Pooled mosquitoes should be accurately identified and grouped by species, site, and week of collection. Pooled mosquitoes should either be sent to the Norfolk Department of Public Health Laboratory (NDPHL) or to the State Division of Consolidated Laboratory Services (DCLS) laboratory in Richmond for testing (see Attachment F). It is best if pools are frozen until shipment or delivery to the laboratory, and shipped in insulated containers packed with dry ice. Target species for laboratory submission vary by disease/pathogen of concern. For WNV, 19 species are currently tested, and seven species are given priority for testing. For EEE, 14 species are tested and four are given priority. For LAC, four species are tested and three are given priority. Within the *Culex* genus, *Cx. pipiens*, *Cx. salinarius*, *Cx. restuans*, and *Cx. erraticus* are tested. The mosquito *Culiseta melanura* is also tested. The *Aedes* species tested include *Aedes albopictus* (the Asian tiger mosquito) and *Ae. vexans*. *Ochlerotatus* species that breed in containers (i.e., *Oc. atropalpus*, *Oc. triseriatus,* and *Oc. japonicus*) are considered important to test. Several other salt marsh and floodwater *Ochlerotatus* species are also recommended for testing (see Attachment F). The *Culex* species and the *Culiseta melanura* mosquito might all act as important <u>primary vectors</u> (bird feeding species that amplify WNV in the bird population). All of the above species except *Cx. restuans* and *Cs. melanura* may also act as <u>bridge vectors</u> (species that can transmit WNV from birds to humans or other mammals). Except for *Cs. melanura*, and *Cx. erraticus*, all of the above listed species have been tested and proven to have WNV vector competence in laboratory trials. Field collected pools of each of the above listed species have tested positive for WNV in the United States. Early season pool submissions should concentrate on primary vector species involved in amplification of the virus in the bird population. Once WNV has been detected in the local bird or primary vector population, pooling and testing efforts should also concentrate on bridge vector species of mosquitoes.

B. Phased Surveillance Response Plan

The phased response plan provides recommended levels of surveillance activity during different times of the year.

1. **Level I -** Winter weather, little or no adult mosquito activity present.

    - **Larval surveillance:** Use maps, windshield surveys, and walking surveys or aerial surveillance to identify and map the locations of wet or flood prone areas, and other potential mosquito breeding habitats.

    - **Adult surveillance:** Analyze previous year's surveillance records of mosquito activity to help determine future target locations for surveillance and control activities.

2. **Level II -** Early mosquito breeding season (April – May), adult mosquito activity present.

    - **Larval surveillance:** Conduct larval dipping in suspected habitats to identify mosquito breeding areas.

    - **Adult surveillance:** Conduct trapping and collections in suspected and identified problem areas to identify the species present and to monitor for vector species. Target surveillance to detect primary vector species (*Culex* species) by extensive use of gravid traps and CDC-light traps.

3. **Level III -** Early Summer thru Fall (June – October), mosquito larvae and adults present, potential WNV activity in region.

    - **Larval surveillance:** Seek out mosquito habitats and conduct investigative larval dipping. Conduct weekly larval mosquito surveillance in identified breeding habitats.

    - **Adult surveillance:** Use both gravid traps and CDC-light traps to detect primary vector species. Gravid traps are the best means of capturing *Cx. pipiens* or *Cx. restuans*, and CDC light traps are the best means of collecting the other potential primary vector species (*Cx. salinarius*, *Cx. erraticus* and *Cs. melanura*). If possible, conduct regularly scheduled (weekly) adult mosquito surveillance at identified problem areas using light traps and gravid traps. Also, focus attention on suspected important bridge vector species such as *Aedes albopictus*, *Ae. vexans*, *Ochlerotatus triseriatus* and *Oc. japonicus*. Submit pooled vector mosquito species to laboratory for testing.

IV. MOSQUITO CONTROL

The safest, most effective mosquito and arbovirus control programs are based on the practice of Integrated Pest Management (IPM). The basic theory behind IPM is to base control decisions such as target area, time of application, and control method on surveillance findings and knowledge of the pest, and to apply the best and most appropriate control method(s) or pesticide(s) for each situation. By employing a range of different control methods and pesticides, technicians can deal with various species of mosquitoes during all stages of their life cycle. IPM methodologies also decrease the development of pesticide resistance by minimizing reliance on any one type of pesticide/mode of action, and by minimizing the frequency and volume of application through appropriate targeting.

The way each IPM component is utilized should be tailored to best meet the public health needs. The application of pesticides for mosquito control should be based on surveillance data and knowledge of environmental conditions. To be effective, control activities must be directed towards the specific target mosquito species. Therefore, surveillance is necessary to identify local mosquito populations, and the specific biology and habits of the target mosquitoes must be well understood.

The Norfolk District will undertake water management projects on the CIDMMA where practicable. These projects should include drainage maintenance of ditches and other man-made structures that may collect temporary bodies of water, removal of artificial containers that may catch and hold rainwater, larvicidal treatments of habitats that cannot be drained, removed or otherwise changed, and the stocking of mosquito eating fish into certain habitats.

Adequate control of immature and adult mosquitoes may require the application of insecticides. The decision to initiate insecticide use should be based on an evaluation of its benefit(s). When choosing insecticides, preference should be given to effective products or chemicals that are least toxic to humans and the environment. Commercial applicators that apply insecticides for mosquito control must be certified in Public Health Pest Control (Category-8) in accordance with the *Virginia Administrative Code*, sections: 2VAC20-51-10 through 2VAC20-51-90 (Regulations Governing Pesticide Applicator Certification). These regulations are available through the VA General Assembly website [http://legis.state.va.us/Laws/AdminCode.htm].

A main goal of this IPM is to provide mosquito control guidelines for the reduction of mosquitoes at the Craney Island Dredged Material Management Area.

A. Source Reduction

The alteration or elimination of mosquito larval habitats is the most effective and economical method of providing long-term mosquito control. In salt marshes, ditch plugs and other water control structures should be removed or modified to permit daily tidal inundation to occur. The daily tidal exchange eliminates mosquito breeding and eventually restores the area to a productive salt marsh.

Open Marsh Water Management, which includes the selective excavation of ponds, pond radials, and ditches, is effective in eliminating mosquito-breeding sites and providing permanent habitat for mosquito-eating fish.

Removal of *Phragmites australis*, common reed, is an effective way of reducing mosquito-breeding habitats. Application of herbicides is necessary to maintain areas where phragmites thrives. Mowing, burning, or mechanical removal alone only encourages the spread of this invasive plant. The approved herbicides for use at CIDMMA include Rodeo™ and Habitat™. These herbicides can be applied aerially, by truck, or backpack.

B. Natural Predators

Mosquito-breeding habitats may be stocked with fish, such as mosquito fish (ex *Gambusia holbrooki*), to control mosquito larvae. Habitats where fish may be used to control mosquitoes include storm water retention ponds and stagnant ditches. Other fish species, such as fathead minnows, freshwater killifish, and certain species of sunfish may also be used to control mosquito larvae and pupae. Care should be taken to avoid stocking mosquito fish into areas that harbor game fish, as many larva-eating fish will also feed on game fish fry.

C. Pesticides

Portsmouth residents should be provided accurate and precise advance information on when and where aerial pesticides will be applied so that citizens who wish to avoid exposure may take cover and/or take action to protect pets and domestic animals including managed honeybee colonies, and aquaculture projects. Among various methods of informing the public, such as the media, one of the easiest ways to provide this advance notice is to establish a telephone hotline, publicize its number and record daily updates. Broad scale, aerosol/fog insecticide applications that cover areas that have not been surveyed or determined to have active mosquitoes, are not in keeping with prudent IPM practices. Targeted, focused and limited aerosol/fog application should be based on sound, scientific surveillance indicators.

Pesticide application personnel, in particular, are at risk from direct toxic effects of insecticides, and proper precautions must always be taken when handling, mixing and applying pesticides. Equipment used for applying pesticides must be properly calibrated to dispense the pesticide according to label specifications. Whenever any pesticide is applied, the law requires that the directions outlined on the pesticide label be carefully followed. The relative risks (toxicity) associated with the currently approved mosquito control insecticides, both larvicides and adulticides, are discussed in the *Supplement to the Environmental Assessment for the Aerial Dispersal of Pesticide for Mosquito Control* (2005).

1. Larvicides

Larval mosquito control targets immature mosquitoes in their aquatic habitat before they become flying, biting adults. In general, larval control is the most effective method of controlling some mosquito populations, has the least effect on non-target species, and is applied to the smallest area of the environment. For example, one can treat an acre of aquatic habitat to control mosquito larvae, but if one waits until the adults have emerged and dispersed, one may need to treat 500 acres to kill the adults that emerged from that acre of habitat. The Norfolk District may conduct their own larviciding activities, or contract with commercial pesticide applicators to conduct larviciding operations. Larvicides may be applied by hand, or with powered backpack mounted, vehicle mounted or aircraft mounted equipment. Aircraft application of larvicides is most practical when large areas of inaccessible terrain need to be treated quickly (i.e. containment cells). The larvicides that can be used for mosquito control at CIDMMA include the following:

- Bacterial larvicides, such as *Bacillus thuringiensis* var. *israelensis* (a toxin from a killed bacteria), and *Bacillus sphaericus* (a live bacterial spore) can be used successfully in a broad range of freshwater habitats, but are somewhat unpredictable in salt marsh habitats. *Bacillus thuringiensis* (***Bti***) based larvicides are sold in a variety of formulations (liquid, granule or briquet) under a wide variety of trade names such as: Mosquito Dunks®, VectoBac™, Aquabac™, Bti Briquets™. ***Bti*** based larvicides are quite effective against members of most mosquito genera, but may be slightly less effective on members of the *Culex* genus. *Bacillus sphaericus* (***Bs***) based larvicides are sold under the trade name VectoLex™. ***Bs*** is highly effective against species in the *Culex* genus, but is not effective against Asian tiger mosquitoes and several other species of *Aedes* and *Ochlerotatus* mosquito species. ***Bs*** works very well in polluted water, where it may be self-perpetuating. Bacterial larvicides are most effective when used against mosquitoes in the 1st through 3rd larval growth stages, but will not control late 4th stage or pupal stage mosquitoes.

- Biochemical larvicides, which contain an insect growth regulator called methoprene, are sold under the trade name Altosid®. Methoprene is an insect hormone that prevents immature mosquitoes from developing into adults. Altosid® products are labeled for use in a wide variety of natural and artificial aquatic habitats and are effective for use in salt marshes. Altosid® is most effective when used against mosquitoes in the 1st through early 4th

larval growth stages, but is not effective against late 4th larval stage or pupal stage mosquitoes.

2. Adulticides

Adult control consists of two different techniques. One technique is the application of Ultra Low Volume (ULV) aerosols, or “fogging”. The other technique is the application of “barrier treatments”.

Aerosol/fog applications are the most widely used method of adult mosquito control and involve a volumetric treatment of air by the dispersal of very fine aerosolized droplets that are light enough to float on the air and be carried over a large area by wind. These small droplets (generally ranging from 1 to 40 microns in size) float on air currents and intoxicate the flying mosquitoes that are impacted by them. Fogs/aerosols are dispensed in very low doses (ounces per acre) and do not leave any significant residual pesticide layers on surfaces within treated areas. Aerosols and fogs generally only kill mosquitoes that are in flight because mosquitoes that are resting in sheltered areas are not impacted by sufficient numbers of droplets to get a toxic insecticide dose.

Ultra Low Volume (ULV) fogs and aerosols are generated with dispensing machines that physically split a liquid insecticide into very small droplets of a relatively uniform size (narrow size range). Most ULV machines can be set to produce droplets of a particular size within the 1 to 50 micron size range. The production of ULV aerosols/fogs does not require that the liquid insecticide concentrate be mixed with a carrier liquid such as oil or water, so a very small volume (ultra low volume) of liquid insecticide can be converted into a fog/aerosol of relatively pure insecticide and be dispensed over a wide area.

Mosquito aerosol and fog applications should be made using properly maintained and calibrated ULV machines and foggers. Adulticide aerosol/fog applications may be made by equipment that is hand held, or mounted on backpacks, all terrain vehicles, trucks, or on fixed-wing or rotary-wing aircraft. Aerial applications of mosquito control insecticides are useful for rapidly treating large areas that cannot be easily accessed or covered in a timely manner by ground based spraying equipment. Due to the speed of coverage, the large area that can be treated, and the uniformity of the coverage, aerial applications are more effective in controlling mosquitoes than ground-based applications. Depending on the shape and size of the area to be sprayed, the advantages and drawbacks of using either fixed-wing or rotary-wing aircraft for dispersing pesticides should be considered.

Timing and conditions for adulticide aerosol/fog applications must be appropriate for treatments to be effective. Depending upon the target species, the greatest efficacy will be achieved when applications are made during periods when the target species is in flight. For example, *Culex pipiens*, a primary vector of WNV, is a nighttime biter, and applications should be made starting at dusk and continuing into the nighttime hours. The fogging of daytime flying mosquitoes can be difficult. Aerosol/fog applications made during daylight hours are often ineffective because warm convective air currents rising from close to ground level will carry the fine aerosol/fog droplets up into the sky. Daylight fog applications can be effective only when there are no convective currents and this may occur during early morning hours, on overcast days, or in heavily shaded areas. Fogging applications should be made when air temperatures are above 50° F because mosquitoes will not fly at lower temperatures. It is preferable to make fogging applications when wind speeds are from 3 to 5 mph. To avoid poor pesticide coverage due to excessive pesticide drift and dilution, fog applications should not be made when wind speeds exceed 10 mph. Applications should not be made from either ground vehicles or aircraft during periods of dead calm because the fog/aerosol will not be carried from the road or aerial spray swath into target areas.

Barrier treatments involve the application (spraying) of residual liquid pesticides on surface areas. A residual pesticide barrier applied to a surface can kill adult mosquitoes that subsequently land on the treated surfaces. Depending on the surface treated, and the occurrence of rain or other factors that might degrade a residual insecticide layer after treatment, residual barrier treatments may be effective for several days to several weeks after application. Barrier treatments are applied to foliage, vegetation, the eaves, ceilings and walls of houses, or any other place where adult mosquitoes are known to land and rest. Barrier treatments may be applied using a simple liquid insecticide sprayer with a fan nozzle, or may be applied using a ULV machine, thermal fogger, or air-blast fogger set to dispense mist-sized droplets in the 40 to 100 micron size range. Portable ULV machines are best used to apply barrier treatments to plants and foliage because relatively small quantities of insecticide can be used to apply a uniform layer of insecticide on a large area of foliage.

D. Phased Control Response Plan

1. **Level I -** Winter weather, little or no adult mosquito activity present.

   - Plan and organize mosquito control program elements for larval and adult control. Identify habitats where larval control measures can be applied. Scout and identify locations where drainage/source reduction activities could be applied and identify areas that might require larvicidal control methods once the mosquito season commences. If resources are available, conduct ditching and other source reduction operations.

2. **Level II -** Mosquito-breeding season, adult mosquito activity present.

   - Where appropriate and resources permit, conduct ditching, drain cleaning, fine-grading, and other habitat modification activities for source reduction. Conduct larval control of vector species in identified breeding habitats where source reduction (habitat modification) is not possible. Consider adult mosquito control where large primary vector populations are detected.

3. **Level III -** Mosquito larvae and adults present.

   - Continue source reduction and public education programs, and enhance larvicide programs to target vector-breeding habitats in areas of increased WNV epizootic activity. Consider use of adult control tactics in areas where vector species have escaped larval control and where evidence of WNV has occurred. Plan an emergency mosquito control program to be ready if conditions ever reach a state where such operations are needed.

V. ABBREVIATIONS

CIDMMA: Craney Island Dredged Material Management Area
EEE: Eastern Equine Encephalitis
IPM: Integrated Pest Management
LAC: LaCrosse Encephalitis
MIR: Mosquito Infection Rate
WNV: West Nile Virus
ULV: Ultra Low Volume